THE WEATHER AND CIRCULATION OF SEPTEMBER 1964

Abnormal Tropical Storminess

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1. WEATHER HIGHLIGHTS

Tropical storms were unusually numerous in the Pacific and the Atlantic during September 1964. Over the United States severe flooding occurred in southern sections while severe drought persisted in the Northeast.

Hurricane Dora was an outstanding feature of weather in the United States. In Florida it caused record-breaking winds of 82 m.p.h. at Jacksonville, tides 4 ft. higher than previously recorded off St. Augustine, and tides 10 ft. above normal at Mayport. Extensive flooding accompanied the storm as rainfall accumulations exceeded 10 in. over an estimated 10,000 sq. mi. One storm total at Mayo, Fla., was 23.73 in. Only one fatality was directly attributable to the storm, according to preliminary reports, but property damage was estimated at more than $200 million.

Elsewhere in the Nation floods occurred in southern Arizona and Texas. At Tucson, Ariz., 3.05 in. of flood-producing rain fell in 24 hours on the 9–10th. In southwestern Texas rainfall ranged up to 15 in. for 2 days near mid-September causing flash floods in the Rio Grande Valley and serious flooding in the upper Nueces Basin. Squall line and frontal showers with totals ranging to more than 10 in. the next weekend caused further inundations in the Nueces River Basin and flooding of the Trinity River Basin. On the 25th locally heavy showers along a cold front brought up to 7 in. of rain and flooded streets in Corpus Christi, Tex.

Drought continued in the Northeast, where Albany, N.Y., reported the least September rainfall since records began in 1826, and the sixth consecutive month with subnormal amounts. Northern California and the adjacent part of Nevada were also dry with numerous forest fires. Reno, Nev., reported 99.7 percent of possible sunshine for the month.

2. TROPICAL STORM ACTIVITY RELATED TO 30-DAY MEAN AND 5-DAY MEAN CIRCULATIONS

Some of the features of the mean 700-mb. circulation for September 1964 (figs. 1, 2) are believed conducive to the formation of tropical storms (see [1, 2]). In the Atlantic both low-latitude troughs were deeper than usual while the subtropical High was abnormally strong and displaced slightly northward from normal. The distribution of the height anomaly indicates faster than normal subtropical easterlies. These factors, plus the interaction with short-wave westerly troughs, may account for the numerous tropical storms in the Atlantic despite the unfavorable southward position of the mean 700-mb. jet (fig. 3).

Five tropical storms originated in the Atlantic and Caribbean in September, whereas the expected number is three. Four of these developed to hurricane intensity (Hilda on October 1). Most of the storms followed paths suggested by the average monthly circulation (figs. 1, 2). Hurricanes Ethel and Gladys (fig. 4) curved northward through the western Atlantic trough and tropical storm Florence stayed in the eastern trough. Hilda formed in another trough near western Cuba. Only the path of Dora, while west of 70°W., was apparently unrelated to the monthly mean 700-mb. flow.

In the Pacific the subtropical ridge (fig. 1) and the 700-mb. height anomaly (fig. 2) were much more zonal and extensive than in the Atlantic. These characteristics and the strong easterly flow in the subtropics (fig. 3) apparently encouraged the development of tropical storms (seven observed against five expected), but inhibited their recurvature northward. A single typhoon recurved into the westerlies (fig. 5) compared to 56 percent expected.

Five-day mean 700-mb. charts showing paths of concurrent tropical cyclones in the Atlantic (fig. 6) reveal many details of the circulation that are obscured in the mean for September, such as interaction between the easterlies and waves in the westerlies. During September 3–7 (fig. 6A) hurricane Cleo became extratropical in a westerly trough which was shearing from the easterly trough containing hurricane Dora. As Ethel approached Dora and intensified late in the period, the latter began to curve westward.

By September 8–12 (fig. 6B) an east-west ridge was bridged solidly north of hurricanes Dora and Ethel. Slow motion, typical near the time of recurvature, occurred late in this period; this helps to account for the large rainfall accumulations with Dora.

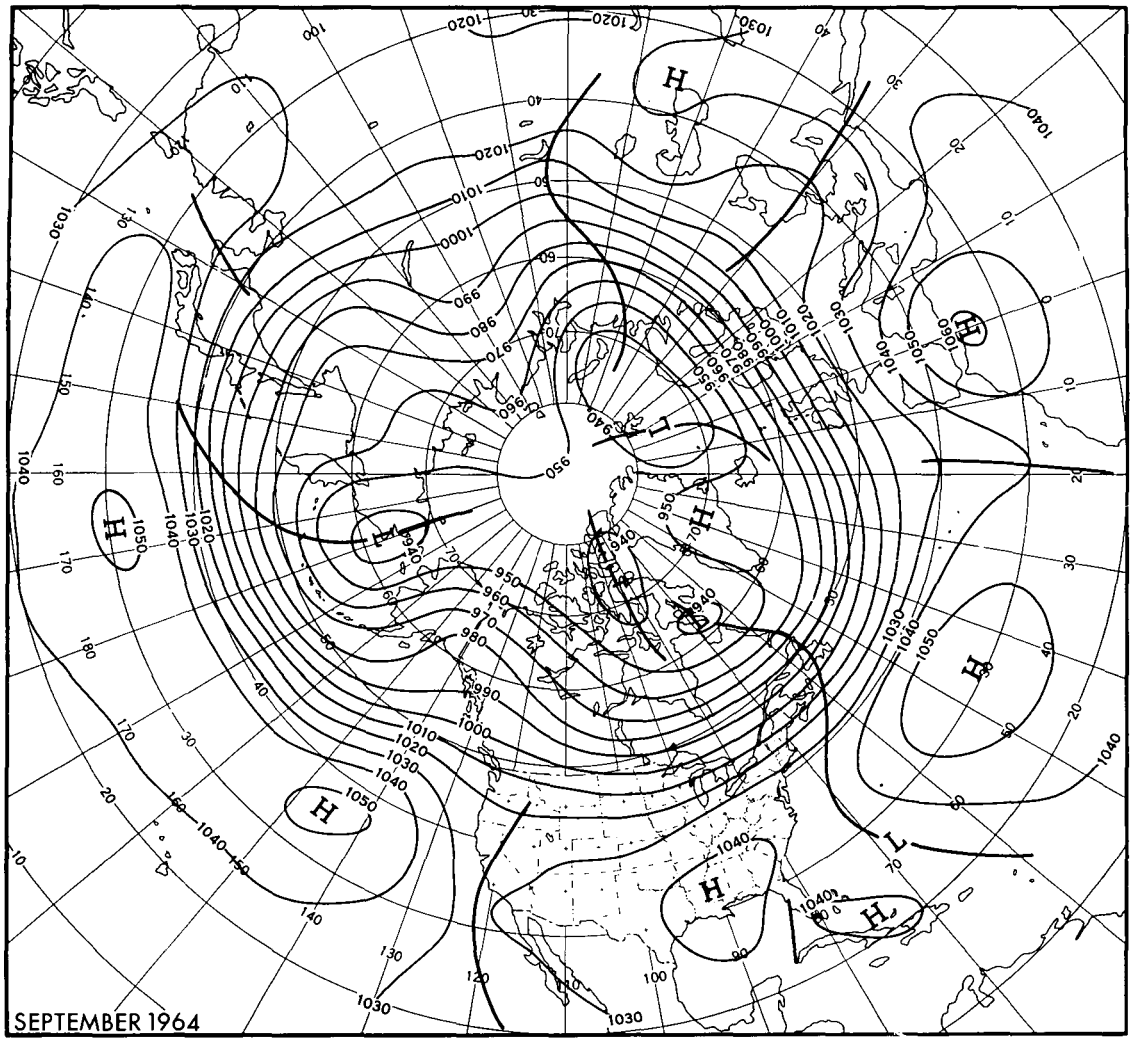

FIGURE 1.—Mean 700-mb. contours (tens of ft. at 100-ft. intervals) for September 1964. Northward recurvature of tropical cyclones was favored in the western Atlantic but not in the western Pacific.

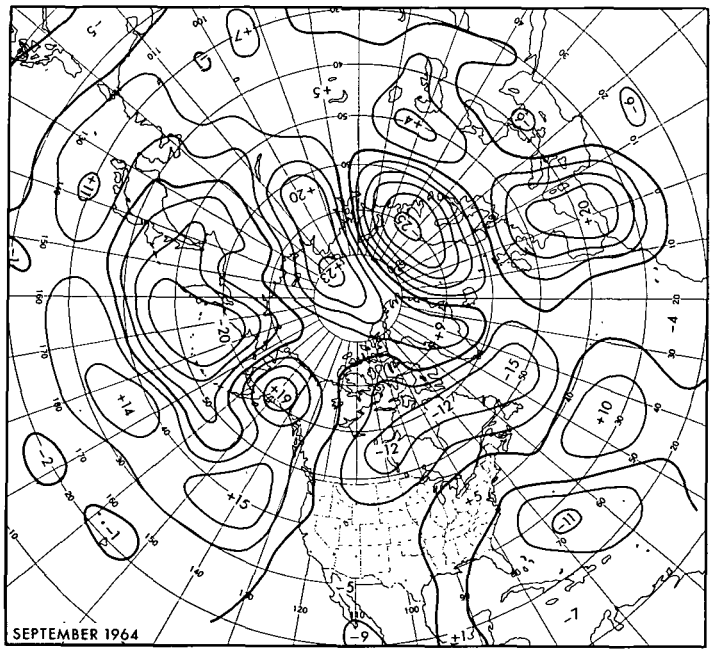

FIGURE 2.—Mean 700-mb. height departures from normal (tens of ft., with zero isopleth heavy) for September 1964. Distribution of height anomalies was conducive to development of tropical cyclones.

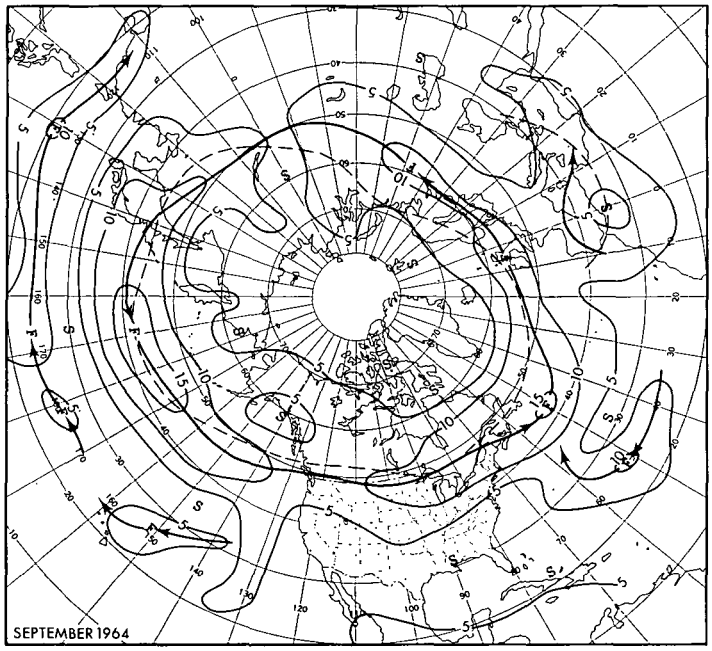

FIGURE 3.—Mean isotachs (meters per second) at 700 mb for September 1964. Solid arrows indicate principal axes of maximum wind speed and dashed lines the normal. Westerly jet was south of normal around most of hemisphere.

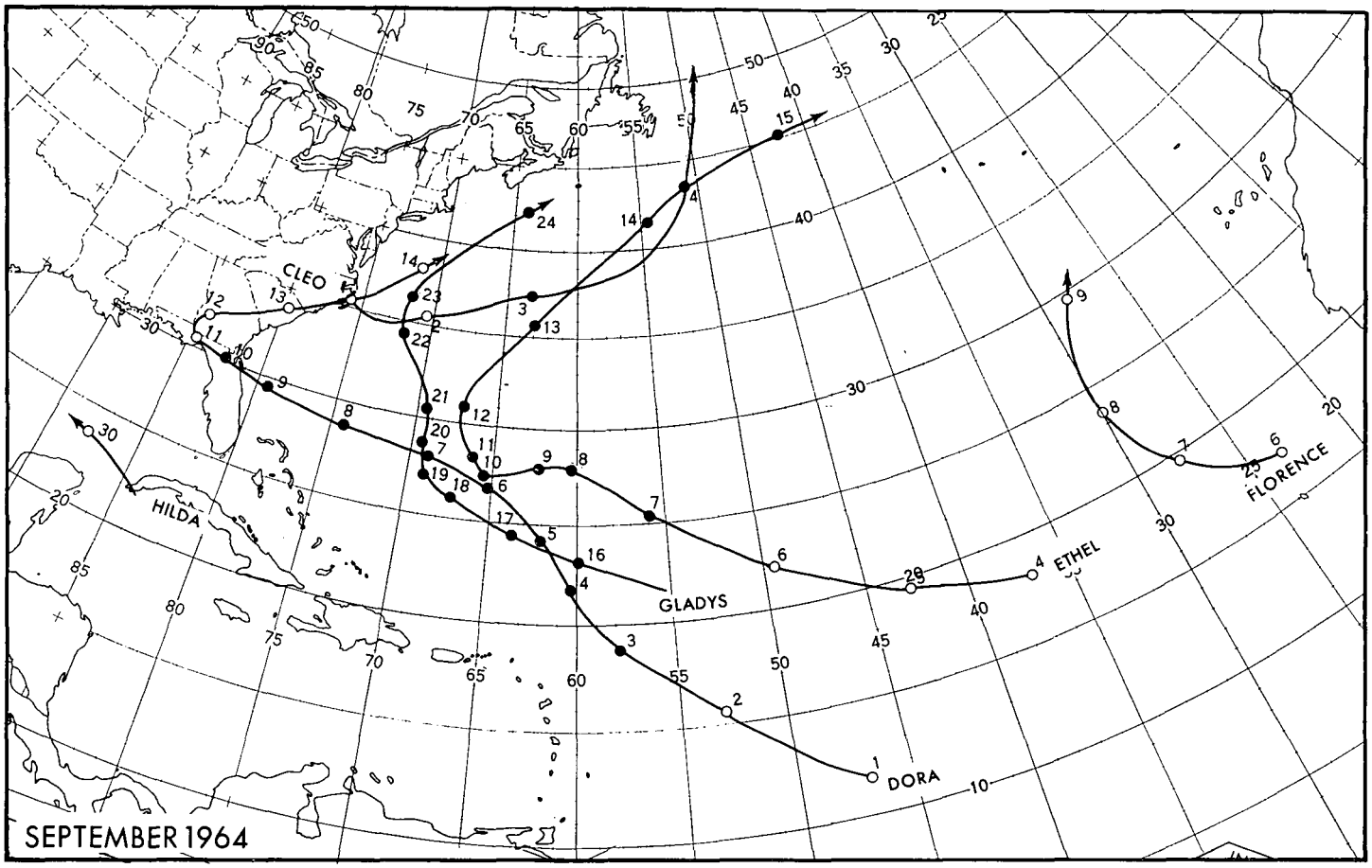

FIGURE 4.—Preliminary tracks of Atlantic and Caribbean tropical cyclones during September 1964. Circles (open for tropical storms and solid for hurricanes) with dates indicate 1200 GMT positions.

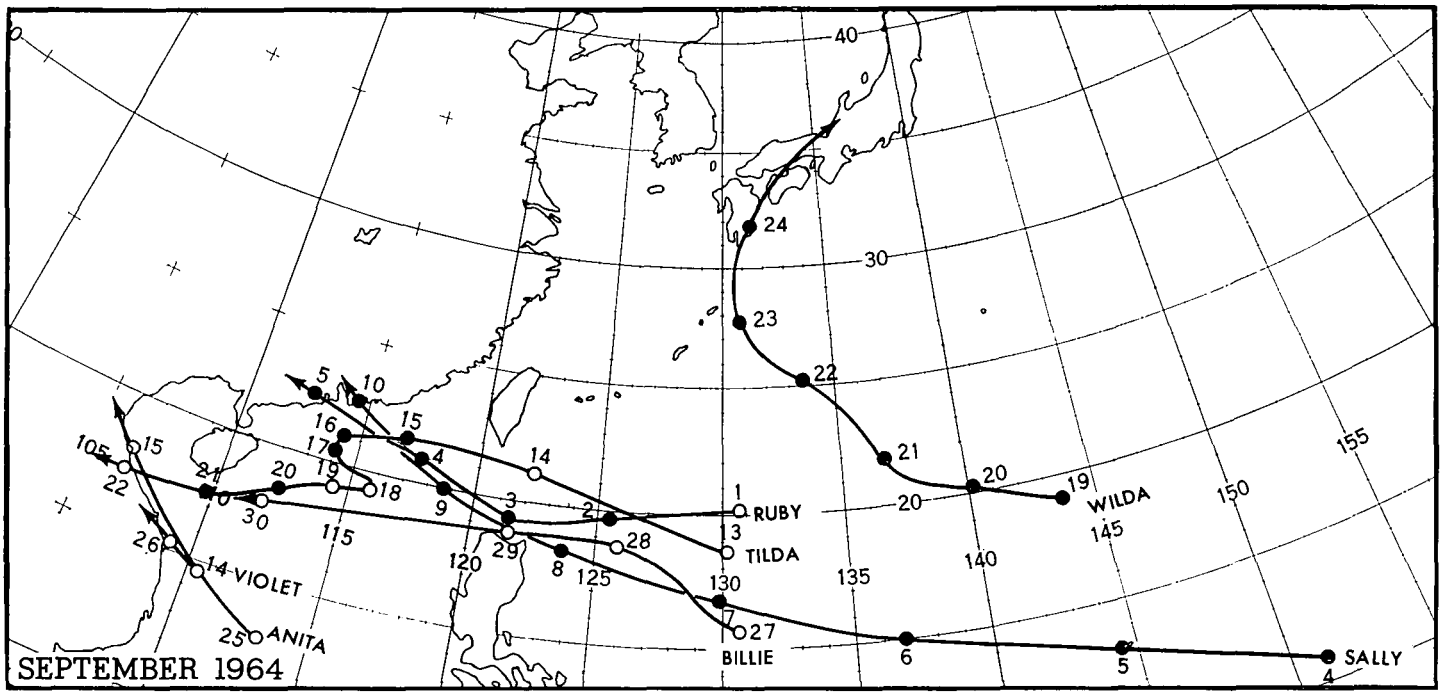

FIGURE 5.—Preliminary smoothed tracks of Pacific tropical cyclones during September 1964. Circles (open for tropical storms and solid for typhoons) with dates indicate 1200 GMT positions.

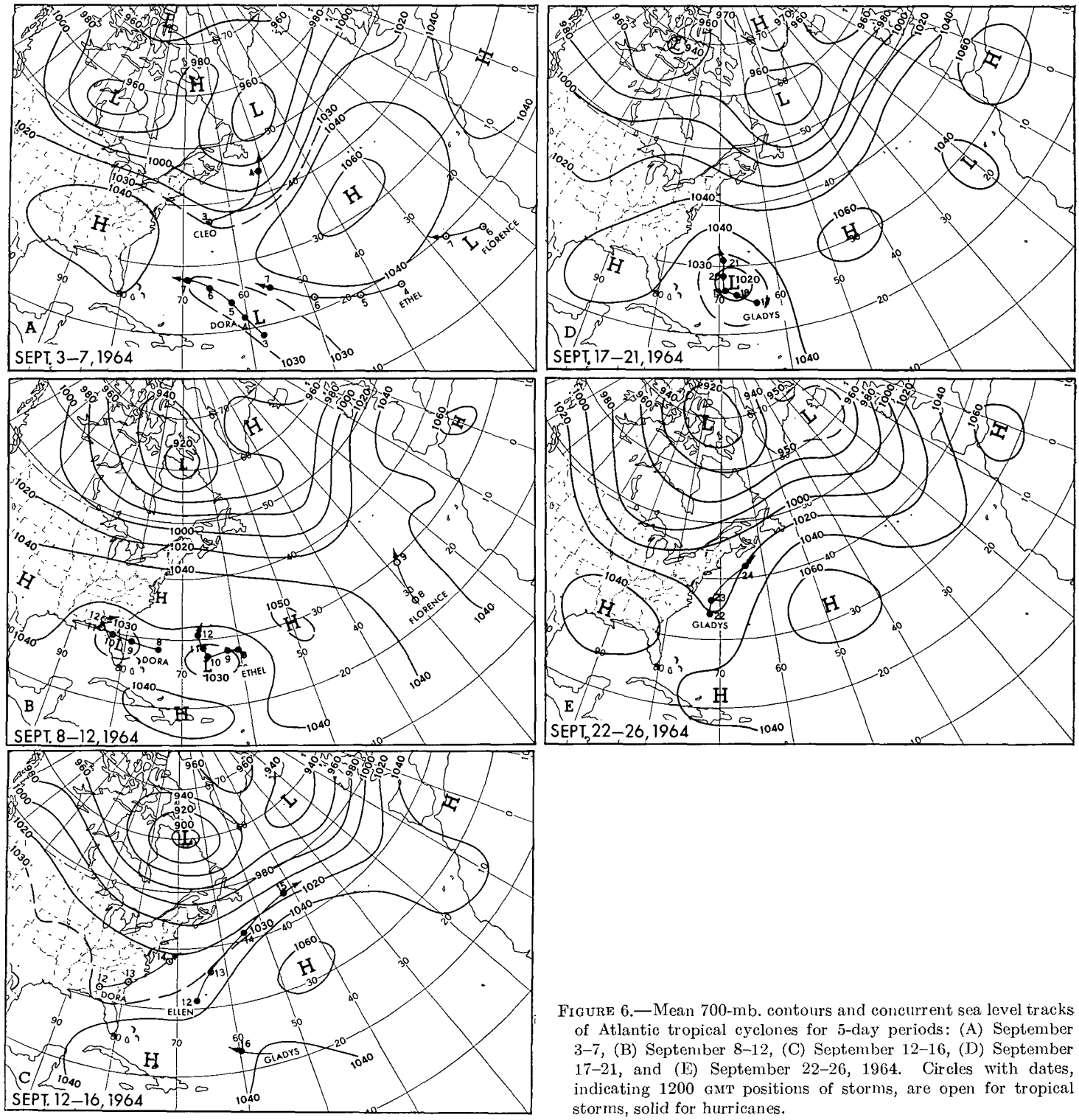

FIGURE 6.—Mean 700-mb. contours and concurrent sea level tracks of Atlantic tropical cyclones for 5-day periods: (A) September 3–7, (B) September 8–12, (C) September 12–16, (D) September 17–21, and (E) September 22–26, 1964. Circles with dates, indicating 1200 GMT positions of storms, are open for tropical storms, solid for hurricanes.

During the next period (fig. 6C) Dora and Ethel moved into the westerlies where they accelerated and became extratropical; storm Gladys became a hurricane by the 16th. High pressure persisted between the trough with Dora and Ethel and the easterly trough with Gladys through the next period (fig. 6D). Though bypassed by the strong polar trough, Gladys decelerated and began slow recurvature northward.

The western Atlantic trough extended to the Caribbean from mid-latitudes during the final period (fig. 6E) as Gladys became extratropical. Hilda formed in the cyclonic region near western Cuba on the 29th (see fig. 4).

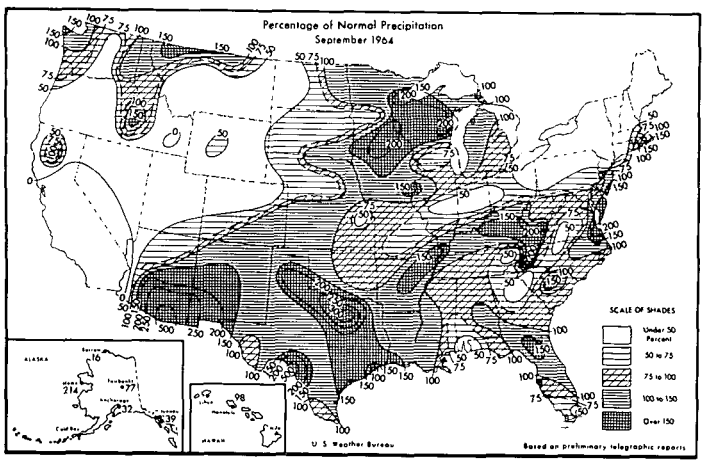

FIGURE 7.—Percentage of normal precipitation for September 1964. Drought was relieved in southwestern Texas, southeastern Minnesota, and Middle Atlantic Coast, but continued in the Northeast. (From [3].)

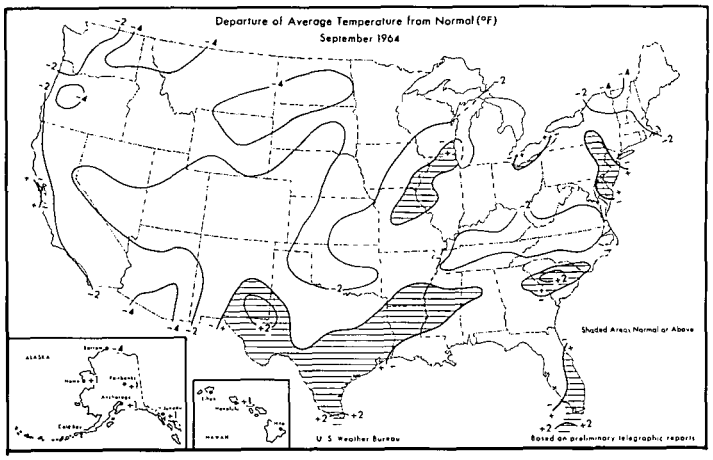

FIGURE 8.—Departure of average temperature from normal (°F.) for September 1964. Most of the United States was cooler than normal. (From [3].)

3. CIRCULATION IN THE WESTERLIES

In the westerlies there were three broad cyclonic regions with large negative height departures, separated by relatively narrow ridges. Wind speeds south of the large negative centers were faster than normal by as much as 5 m.p.s. off Newfoundland, 6 m.p.s. over northern Russia, and 8 m.p.s. south of the Bering Sea. Wind speeds along the mean 700-mb. jet were slower than normal only through the strong ridge over Siberia, where the circulation is usually cyclonic in September. In general the belt of maximum west winds was observed south of its normal position around the Northern Hemisphere.

While the westerlies tended to split in the eastern Pacific and branch to either side of the Gulf of Alaska, a strong connection was kept between the Yukon ridge and the subtropical ridge. Height departures downstream were negative from central Mexico to the Canadian prairies and eastward to the north-central Atlantic (fig. 2).

4. PRECIPITATION

Though rainfall totals with slow-moving Dora were large, greater abnormalities of precipitation occurred elsewhere in the United States. At Tucson, Ariz., the record-breaking total of 5.11 in., and another accumulation in the Rio Grande Valley, were more than five times the normal September rainfall (fig. 7). Other record high totals were 10.67 in. at Dallas, Tex., 6.74 in. at Green Bay, Wis., and 12.26 in. at Norfolk, Va.

Much of the heavy precipitation was associated with frontal activity. Heavy showers and thundershowers were set off in Iowa and Minnesota around the 10th by an active cold front which caused more showers in Texas a few days later. Stable waves along slow-moving fronts helped to produce as much as twice the normal rainfall for the month in part of the Ohio Valley. Moisture transported northward from tropical storm Tillie (which dissipated west of Baja California) probably contributed to the heavy rains in southern Arizona on the 9–10th. Hurricane Cleo was responsible for 4 in. of rain in parts of southeastern Virginia on September 1. Excessive precipitation could be expected over the North Central States in the mean cyclonic flow, and in parts of the Southwest with average southerly flow of warm, moist air from the Gulf of California and the Gulf of Mexico.

Over the Northeast, however, the average 700-mb. flow was anticyclonic with respect to normal (fig. 2) and drought continued over New York, New England, and parts of Pennsylvania. Much of the West, with a slight northerly component of anomalous flow, was dry except for spotty precipitation in the mountains.

5. TEMPERATURE

Over the United States most temperatures averaged below normal in September (fig. 8). This relatively cool pattern was consistent with negative height anomalies in the West but not with positive height departures from the Ohio Valley eastward. Recurrent rainfall along retarded fronts in much of this region, with associated cloudiness, could account for the coolness. Cloudy, rainy weather also helped to reduce temperatures to the record low average at Tucson, Ariz. (76.3° F.) and at Missoula, Mont. (51° F.).

Coolness in parts of the West has prevailed during most of 1964. By the end of September subnormal temperatures had persisted for seven consecutive months at Pendleton, Oreg., Walla Walla, Wash., and San Diego, Calif.; eight months at Kalispell, Mont.; and ten months at Yuma, Ariz.

REFERENCES

1. J. Namias, "Long Range Factors Affecting the Genesis and Paths of Tropical Cyclones," *Proceedings of the UNESCO Symposium on Typhoons, Tokyo, 9–12 November 1954*, 1955, pp. 213–219.
2. E. M. Ballenzweig, "Relation of Long-Period Circulation Anomalies to Tropical Storm Formation and Motion," *Journal of Meteorology*, vol. 16, No. 2, Apr. 1959, pp. 121–139.
3. U. S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. LI, No. 40, Oct. 5, 1964.